NOTES ON NUMERICAL VARIATION IN THE DAISY

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Numerous observers, both in this country and in Germany, have given attention to numerical variations in the ray florets of the Compositae. For the investigation of the subject the common daisy, perhaps, has been most frequently used. The usual method of study has been simply to count and tabulate the ray florets for a number of heads collected from some prescribed locality. The results of such observations seem to show that the number of ray florets in the daisy is subject to a considerable amount of variation; but when a frequency curve is plotted, more or less definite modes become evident, one on the 21-ray line being especially prominent.

With a view to getting more data, I examined 4000 heads during the summer of 1905, from which I obtained results that agree in general with those previously obtained by Tower, and by Pearson and Yule from a much smaller number of heads, except that their data do not demonstrate the presence of a mode on 34, as do my own observations and those of Ludwig (3). For the investigation in question I collected 1300 heads from the vicinity of Tufts College, Medford, Mass.; as many more from Norway, Oxford County, Maine; and 1400 from Dennis, Cape Cod, Mass. In these lots 12 was the lowest number of rays found in any one head and 40 was the highest. The total number of rays produced by the whole lot was

TABLE I

Distribution of rays for 4000 heads collected at Medford, Norway, and Dennis

Rays	Heads
12	1
13	9
14	4
15	9
16	12
17	12
18	25
19	49
20	135
21	423
22	370
23	295
24	278
25	216
26	204
27	176
28	191
29	192
30	184
31	224
32	218
33	266
34	303
35	115
36	47
37	27
38	9
39	3
40	3

107,464, which gives a mean of 26.866 to the head. The distribution of these rays is indicated in Table I. It will be observed that were these figures plotted the result would be a two-humped curve, indicating modes on 21 and 34.

If I combine with my own figures those given by TOWER (6) and by PEARSON and YULE (4), the resulting table (Table II) will be based on a total of 140,988 ray florets from 5585 heads, collected from five different localities by several different observers. It may be observed that this table indicates modes on 21 and 34. The mean number of rays to the head for this set is 25.242+. These results coincide with those which have been obtained in Germany in that modes are evident on 21 and 34; but differ from them in that no modes appear on 13 or 8, the next lower terms of the Fibonacci series. In fact, out of the whole number only 6 heads had less than 13 rays and none had less than 11. On the whole, then, observations seem to show that the daisy of this country has prevailingly more rays than the European plant, but that the numbers produced fall around the same modes which have the same relative prominence, except that no obvious modes occur on 13 or 8 in the American material so far examined.

TABLE II

DISTRIBUTION OF RAYS FOR 5585 HEADS, BASED ON DATA OBTAINED BY TOWER, PEARSON AND YULE, AND DANFORTH

Rays	Heads
11	1
12	5
13	40
14	43
15	51
16	67
17	67
18	110
19	141
20	313
21	752
22	536
23	390
24	342
25	279
26	252
27	212
28	217
29	219
30	201
31	254
32	242
33	307
34	325
35	122
36	53
37	27
38	9
39	5
40	3

Such facts have generally been construed as indicating that no essential alteration has taken place in the flowers of our daisy since its introduction into this country, but FERNALD (2) has lately called attention to the fact that the common American form is not the typical *Chrysanthemum Leucanthemum* L., but a variety (*pinnatifidum* Lecoq and Lamatte) not usually met with in Germany. Con-

sequently the probablity is that all German data are based on the typical *Chrysanthemum Leucanthemum*, while all American data are doubtless based on var. *pinnatifidum*. In view of this fact the value of comparisons between the two forms may at first seem doubtful, but a slight further consideration of the character of numerical variations of the present kind may throw some light on the way in which such variations should be regarded.

TABLE III

DISTRIBUTION OF RAYS FOR 1300 HEADS COLLECTED IN MEDFORD BETWEEN MAY 27 AND JUNE 14, 1905

Rays	Heads
12	
13	1
14	
15	1
16	
17	
18	3
19	5
20	19
21	78
22	95
23	80
24	84
25	58
26	58
27	72
28	64
29	65
30	68
31	79
32	83
33	121
34	154
35	63
36	20
37	18
38	7
39	3
40	1

SHULL (**5**), working with Aster, concluded that there is no tendency for all the flowers of the same plant to fall in the same mode, but that those that blossom first have the greatest amount of nourishment and therefore show the highest modes. TOWER (**6**) likewise thought that in the daisy the higher modes are met with early in the season, the lower modes later. In other words, it would seem that these authors are inclined not to regard the several modes as indicative of incipient species. My own observations, I think, fully substantiate their views in this particular. A comparison of Tables III and IV will show clearly a change in the predominant mode from 34 in the material collected between May 27 and June 14, to 21 in material collected between July 3 and July 15. Although this comparison may not be taken as certain evidence, inasmuch as the two lots were from different localities, nevertheless there is a strong suggestion here of a connection between mode and season.

Two pairs of tables, one based on material collected at Norway, Maine, the other on material collected at Dennis, Mass., give much clearer evidence of the relation between mode and environment.

The collections from Norway were taken on June 22, 1905, from the two sides of a private road, about 12 feet wide, which several years previously had been run through an open field. The ground slopes in such a manner that the north side of the road receives practically all of the drainage, while the south side is drier and less favorably supplied. Noticing an apparent difference in the daisies of the two sides of the road, I marked a starting point and picked every head within about two feet of the road, till 150 had been collected from each side. The table (Table V) based on the counts shows clearly a tendency for the heads growing on the north side of the road to have a large number of rays, and for those on the south side to have a much smaller number. This difference between the two lots, it seems to me, may be regarded as clearly indicating a relationship between the amount of moisture or nutrition and the number of ray florets.

TABLE IV

DISTRIBUTION OF RAYS FOR 1300 HEADS COLLECTED IN DENNIS BETWEEN JULY 3 AND JULY 15, 1905

Rays	Heads
12	1
13	8
14	4
15	6
16	9
17	5
18	16
19	32
20	62
21	176
22	139
23	99
24	84
25	72
26	75
27	43
28	52
29	66
30	52
31	66
32	64
33	68
34	75
35	14
36	7
37	2
38	2
39	
40	

Very similar results were obtained from two lots of 250 heads, each collected at Dennis, July 13 and 14. One of these lots (Table VI, *B*) was from a rosebush tangle near the sea; the other (Table VI, *A*), was from a dry field near by. These lots likewise show clearly a tendency for plants growing in more moist and richer soil to have a higher number of rays.

These various observations seem to indicate that the number of ray florets in the daisy is in part conditioned by two general factors: an external factor, nutrition; and another, which might possibly be termed internal, namely, the tendency which gives rise to modes. A slight investigation of the latter has led me to believe that the explanation of the

modes is to be sought in an explanation of phyllotaxis. As is well known, this is a subject which has given rise to a great deal of speculation. Although, perhaps, there is even now no satisfactory explanation of the rules of phyllotaxis, the facts themselves are familiar and only a brief reference need be made to one or two simple conditions.

TABLE V

DISTRIBUTION OF RAYS IN TWO LOTS OF 150 HEADS EACH; MATERIAL COLLECTED AT NORWAY, JUNE 22, 1905; LOT *A* FROM SOUTH SIDE OF ROAD; LOT *B* FROM NORTH SIDE OF SAME ROAD

Rays	Heads	
	A	*B*
16	1	
17	4	
18	2	
19	4	
20	20	
21	37	2
22	26	5
23	15	7
24	8	8
25	3	8
26	2	10
27	4	5
28	6	8
29	5	8
30	4	6
31	4	13
32	2	14
33	1	17
34	1	17
35		10
36	1	5
37		5
38		
39		
40		2

As has been frequently pointed out, five-ranked leaves may be regarded as arranged on the stem according to any one of several different schemes. In one light they may be imagined as situated regularly along a line coiled spirally around the stem in such a way that the sixth leaf falls very nearly above the first. In this case, if the line is considered as running around the stem in one direction, it encircles it twice in passing from the first to the sixth leaf; if in the other direction, it encircles it three times in passing between the same two points. On changing the point of view slightly, the leaves may be imagined as all arranged along two parallel spiral lines running in one direction, or along three similar lines running in the opposite direction, in which case either spiral embraces five leaves in each revolution. This is equivalent to regarding the leaves as though they were placed at the points of intersection of two opposite sets of spirals, one composed of two lines, the other of three. Once more, the leaves may be regarded as placed along five nearly vertical but still slightly spiral lines. Of course these are merely different ways of regarding one and the same thing.

While these conditions, on the whole, are quite constant, nevertheless when the stem is increased in diameter or shortened, thereby

bringing the leaves or their morphological equivalents closer together, the parts not infrequently become arranged according to an apparently different scheme. Thus in the umbels of the wild carrot (*Daucus Carota*) peduncles are usually so arranged that they seem to be placed at the intersections of what appear to be lines arranged in the form of logarithmic spirals (see CHURCH 1), eight running in one direction and five in the other; or, if the umbel is large, eight in one direction and thirteen in the other. This arrangement might be considered as differing from the arrangement of five-ranked leaves only in the greater number of intersecting spirals. The point of chief interest in the present connection is that the number of spirals is confined rather constantly to the lower members of the logarithmic series 1, 2, 3, 5, 8, 13, 21, 34, etc.

TABLE VI

DISTRIBUTION OF RAYS FOR TWO LOTS OF 250 HEADS EACH; MATERIAL COLLECTED AT DENNIS, JULY 13 AND 14, 1905; LOT *A* FROM A DRY FIELD; LOT *B* FROM A ROSEBUSH TANGLE NEAR BY

Rays	Heads	
	A	*B*
12	1	
13	6	
14	3	
15	2	
16	6	1
17	3	1
18	7	2
19	12	7
20	22	9
21	55	27
22	27	12
23	23	14
24	12	12
25	16	12
26	13	18
27	4	4
28	3	11
29	7	18
30	5	15
31	7	28
32	5	16
33	5	16
34	6	21
35		2
36		2
37		1
38		1

If now a daisy head be examined carefully, it will generally (perhaps always) be found that the disk florets are so arranged that they appear to be placed at the intersections of two sets of spirals; or perhaps they might be more conveniently regarded as arranged in either of two opposed sets of spirals running from the periphery to the center of the head. I shall speak of the disk florets, therefore, as though they were arranged in two sets of spirals, although each of these sets (which one depending on the point of view assumed) embraces all the florets. There are usually 21 spirals running one way and 13, 21, or 34 running the other way. The set of 21 spirals may be either left-handed or right-handed in direction; but in either case the direction of the spiral is apparently correlated with the arrangement of the

leaves. Only 100 plants were examined to determine this relationship, but among these specimens, which were collected at Norway in June, 1908, I found no exception to the rule that the direction of a set of 21 spirals in the disk is similar to the direction of the shortest line that can be drawn from any leaf on the stem to the next succeeding leaf. That is to say, if a stem was so held that any given leaf faced the observer, and it was seen that the next higher leaf on the stem was toward the left rather than toward the right, then a set of 21 left-handed spirals was invariably found in the disk. Of the 100 heads examined, the 21 spirals were found to be left-handed in 47 cases and right-handed in the remaining 53 cases. Of course the direction of the leaf spirals varied accordingly. There can hardly be any indication of incipient species here, for the arrangement on the branches of large plants is, as frequently as otherwise, reversed in reference to the arrangement on the main stem. I have been unable to trace the transition from the placing of the leaves to that of the flowers, except to notice the above-mentioned correlation.

The ray florets are placed, as one might expect, at the peripheral ends of these spirals. Each of the spirals in the set of 21 generally has a ray floret at its end; and frequently there are no other rays, especially if the other set consists of 13 or 21 spirals. When there are 34 spirals in one set, however, and the head is large, the number of ray florets is frequently increased, when each of the 34 spirals may be terminated by a ray. This case, though common, is less frequent than the other. Instances frequently occur where rays do not develop at the ends of some of the spirals, or (less commonly) where two rays develop on the same spiral. Heads that show more than 34 rays are of this class. In some of the Compositae, for example in Erigeron, where the disk florets are arranged in no more spirals than we find in the daisy, there are many rays; but in such cases several flowers of each spiral develop as rays, while in the daisy there seems to be but slight tendency for more than one flower to so develop.

If the typical *Chrysanthemum Leucanthemum* shows as much tendency for developing more than one ray on some of the spirals as does the var. *pinnatifidum*, it would seem hazardous to regard any

comparison between the numbers of ray florets so far recorded as of taxonomic importance, inasmuch as the variations seem to be merely equivalent to variations in size.

In short, the conclusions these observations seem to warrant are: (1) that the florets in the heads of *Chrysanthemum Leucanthemum pinnatifidum* may be regarded as arranged in either of two sets of spiral lines; or, what amounts to the same thing, in the intersections of these two sets of spirals; (2) that the number of lines in each set is a term of the Fibonacci series; (3) that the number is influenced by external conditions, i. e., the conditions of nutrition affecting size; (4) that one set is composed of 21 spirals, which are in some way correlated in their arrangement with the arrangement of the leaves; (5) that each of the 21 spirals and frequently each of the spirals in the other set tends to have a ray developed at its end—hence the modes noted by various observers; and (6) that these facts supply few if any data of taxonomic value.

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